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QUESTIONS OF THE CONSTRUCTION OF RESONANCE FERRITE RECTIFIERS.(U)
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by

A.L. Mikaelyan, A.K. Stolyarov

FOREIGN TECHNOLOGY DIVISION

EDITED TRANSLATION

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By: A.L. Mikaelyan, A.K. Stolyarov

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В в	*В в*	V, v	Т т	*Т т*	T, t
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И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
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К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
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О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

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QUESTIONS OF THE CONSTRUCTION OF RESONANCE FERRITE RECTIFIERS

A. L. Mikaelyan, A. K. Stolyarov

Questions of the construction of resonance rectifiers in various wave ranges, methods of obtaining temperature-stable characteristics of rectifiers, and also means of lowering the weight and overall dimensions of the rectifiers are examined. The developed prototypes of rectifiers, intended for various applications, are described.

Introduction

In article [1] were examined the main general laws governing the phenomenon of ferromagnetic resonance in a rectangular waveguide with ferrite-dielectric plate. In this case we will not be concerned with specific difficulties, appearing during the development of rectifiers for the decimeter and millimeter ranges of waves.

Furthermore, during the construction of rectifiers frequently additional requirements are imposed on the overall dimensions, weight or standing wave ratio (KSV) of the rectifier.

All the enumerated questions are examined below.

In conclusion are described the prototypes of resonance rectifiers of various types, illustrating the achieved results. These prototypes can be used as a start during the construction of new rectifiers.

Overall dimensions of rectifiers, transmission power and temperature properties

The weight and overall dimensions of a permanent magnet are determined at prescribed frequency by the magnitude of resonance field and the height of the waveguide. The external magnetic field intensity, corresponding to resonance, changes in wide limits depending on the shape and parameters of the ferrite plate. We already saw [1] that the minimum external field is required for a rectifier with thin ferrite plate in plane E.

The greatest external field is required in rectifiers with thin ferrite plate, located in plane H. As already was noted, for this case the field inside the ferrite H_0^i coincides with the field of longitudinal resonance H_{11}. In this case it is necessary to overcome the demagnetizing field [1], which in the case of a thin plate is equal to $4\pi M_0(N_z = 1)$. Thus, for the examined type of rectifier the permanent magnet should create a field, equal to

$$H_0^e = H_{11} + 4\pi M_0. \qquad (1)$$

For other types of rectifiers the working magnitude of the field lies in the interval between the indicated limiting values. As we see, the resonance fields for rectifiers of type E and H are distinguished more sharply, the greater the degree of magnetization of ferrite. For example, on 3 cm wave H_{11} =3570 Oe. Consequently, for ferrite with degree of magnetization $4\pi M_0$=3000 G (this is ferrite NM-2) we have

$$H^e_{0\,мин} = 2350 \text{ э}^{(1)}; \quad H^e_{0\,макс} = 6570 \text{ э}^{(1)}.$$

Key: (1) Oe.

Thus, for type H rectifier a very large field is required. It is obvious that the magnet is this case is obtained so bulky, that the advantage of the resonance rectifier - simplicity of construction - is reduced to zero.

After the presented example, the impression can be created that the type H rectifier is not of practical interest. In fact, this is not so and there are a number of cases when its realization is very expedient.

This occurs primarily with the use of ferrites with low degree of magnetization of saturation, which, as a rule, is on longer waves. For example, on wave 7.7 cm H_{11} =1390 Oe. With the use of ferrite KhMM-1 with saturation magnetization $4\pi M_0$=1050 G we have $H^c_{0\,\text{макс}}=$ =2440 Oe.

For ferrite KhM-3 ($4\pi M_0$=550 G) this value is still less: $H^c_{e\,\text{макс}}=$ =1940 Oe. In this case one should bear in mind that the presented figures pertain to the case of infinitely thin plates. For ferrites of finite thickness the demagnetizing, and consequently, the external field will be smaller than the provided maximum values.

Let us now examine the case of very high frequencies. From the stated it follows that with shortening of the wave the required field intensity is raised, which leads to complication of the magnetic system. For example, if on a 3 cm wave the minimum field was 2350 Oe, then on a 2 cm wave (H_{11} =5350 Oe) it will be equal to 4000 Oe, and

on 1 cm wave (H_{11} =10700 Oe) - over 9000 Oe. Hence it follows that on waves shorter than (approximately) 2 cm the practical realization of rectifiers, in view of the complexity of the magnetic system, is inexpedient *.

FOOTNOTE * On millimeter waves ferroxdures are applied, having large internal (inherent) field of anisotropy, which fulfills the same role as the field of a permanent magnet. ENDFOOTNOTE

Thus, type H rectifiers always require a more complicated magnetic system than type E rectifiers.

This difference is manifested especially strongly in the shortwave part of the centimeter range of waves, where ferrites with large saturation magnetization are used. The weight and overall dimensions of a permanent magnet highly depend on the gap between its poles, which is determined by the height of the waveguide. Decrease of this height on the section, where the ferrite is located, leads to considerable simplification of the magnet and therefore is frequently applied in practice.

The allowable level of power, at which the resonance rectifer

operates, is determined in the final analysis by the maximum power, which can disperse the ferrite without intense overheating. As a rule, this power is equal to the power of the back wave, which is almost completely absorbed in ferrite. In some cases, however, the power, absorbed in ferrite with passage of the wave in forward direction, also can be great. This relates to the use of the rectifier for isolation of the generator from the load, when the power of the back wave (i.e., reflected from load) is very small in comparison with the power of the forward wave.

The maximum power, which the ferrite can scatter, will strongly depend on the rectifier installation. It is obvious that the most advantageous, in this sense, is the case of thin plates, placed on the wide walls of the waveguide, and the least advantageous - ferrite, located in plane E. Thus, type H rectifier will withstand the greatest level of power.

The temperature characteristics of resonance rectifiers are determined mainly by the dependence of the saturation magnetization of ferrite on the temperature. With rise of temperature the magnetization is smoothly decreased and at the Curie point (T_c) becomes zero (Fig. 1).

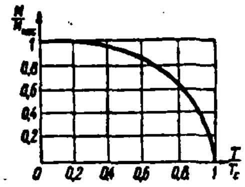

Fig. 1.

Thus, the further the region of operating temperatures is located from the Curie point, the slighter will be the change of magnetization. Fig. 2 shows the measured dependence of saturation magnetization on the temperature for ferrite NM-2, for which the Curie point is around 450° C.

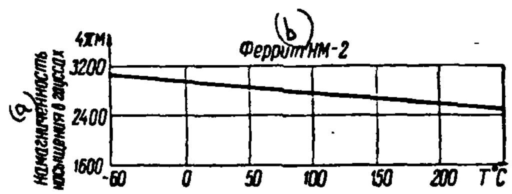

Fig. 2.

Key: (a) Saturation magnetization, in Gauss. (b) Ferrite NM-2.

As we see, in this case the magnetization is changed slightly. It is obvious that for ferrites with lower Curie point, decrease of

magnetization in the same temperature range will occur faster.

Let us now examine how the change of ferrite magnetization affects the parameters of the rectifier.

At present it is established that with decrease of magnetization the losses of back wave will drop (which are proportional to ferrite magnetization) and the resonance field will be changed. From formulas (1) and (5) of article [1] it follows that for type E rectifiers this field will be increased, and for type H rectifiers - decreased. This is well confirmed experimentally. For example in Fig. 3 are presented curves of ferromagnetic resonance for a back wave with two values of temperature. These curves relate to type E rectifier.

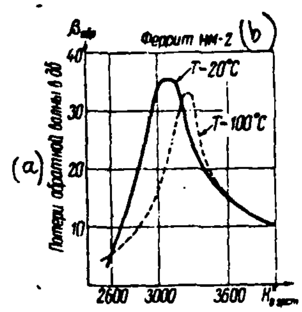

Fig. 3.

Key: (a) Back wave losses in dB. (b) Ferrite NM-2.

Thus, with change of temperature the resonance value of the

field will be changed, which will lead to decrease of back losses and rectifier ratio. This cause will affect the characteristics of the rectifier the most intensely. Moreover, as we will now show, it can be eliminated by the rational selection of the shape and parameters of ferrite. Actually, if for type E rectifier the resonance field is increased with decrease of magnetization, and for type H rectifier it is decreased, then, obviously, it is possible for a certain ferrite to select its shape so that the indicated field would virtually remain constant with change of magnetization in prescribed limits.

The intensity of the external magnetic field, corresponding to ferromagnetic resonance, is determined by formula

$$H'_{рез}=\sqrt{\left(\frac{N_y-N_x}{2}4\pi M_0\right)^2+H_{11}^2}+\left(N_z-\frac{N_x+N_y}{2}\right)4\pi M_0 \quad (2)$$

where N_x, N_y and N_z - demagnetizing factors of ferrite sample along axes x, y and z.

Since the length of the ferrite sample is usually much greater than its lateral dimensions, then in practice it is possible to consider $N_y=0$ (Fig. 4).

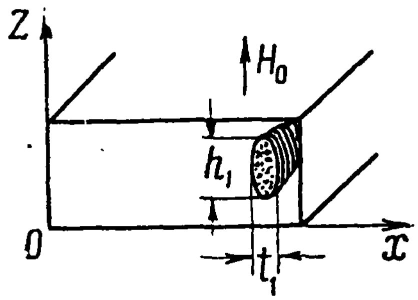

Fig. 4.

Then, considering that $N_z = 1 - N_x$, we obtain

$$H^{e}_{рез} = \sqrt{H_{11}^2 + \left(\frac{N_x}{2} 4\pi M_0\right)^2} - \frac{3N_x - 2}{2} 4\pi M_0. \qquad (3)$$

Hence it is easy to see that with certain conditions $H^{e}_{рез}$ will virtually maintain constancy in some interval of changes of saturation magnetization $4\pi M_0$.

In Fig. 5 are presented calculated curves, making it possible for different ferrites ($4\pi M_0$) to determine the most advantageous shape of the sample (N_x), at which the resonance field barely changes in a rather wide interval of changes of magnetization (i.e., temperature).

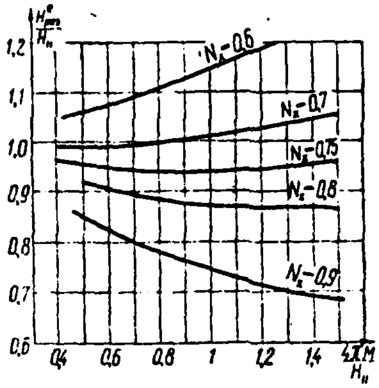

Fig. 5.

In this calculation it was assumed that the ferrite is a cylinder of elliptical cross section. For each N_x the dimensions of the axis of ellipse can be determined by formula

$$N_x = \frac{h_1}{t_1} \cdot \frac{1}{1+h_1/t_1}, \tag{4}$$

where h_1 and t_1 - dimensions of ferrite, designated in Fig. 4.

Thus, during the creation of rectifiers with temperature-stable characteristics it is necessary, first of all, to apply ferrites with high Curie temperature, secondly, to rationally select the average temperature, at which the rectifier is adjusted, and, thirdly, to use ferrite samples with definite shape of cross section.

Difficulties of creation of resonance rectifiers on decimeter waves.

As already was noted, on waves shorter than approximately 2 cm the realization of resonance rectifiers is inexpedient, which is connected with the technical difficulties of creation of permanent magnets.

The advancement of resonance rectifiers toward long centimeter waves runs into difficulties of both technical and principle character. The technical difficulties are connected mainly with the fact that with transition to longer waves the dimensions and weight of the rectifier increase severely and its construction becomes very bulky.

More important factors, limiting the application of ferrites on decimeter waves, are connected, first of all, with the weakening of independent phenomena during ferromagnetic resonance and, secondly, with the increase of magnetic losses in ferrites. Actually, from the basic formula

$$B = 2{,}04 \cdot \left(\frac{f\ (\text{MHz})}{2\Delta H\ (\text{Oe})}\right)^2$$

Key: (a) Mhz. (b) Oe.

it follows that with increase of frequency the rectifier ratio

rapidly drops. If the width of the curve of absorption is assigned, equal to 250 Oe, then we obtain the following values of $B_{макс}$ in different ranges of waves:

$$\begin{array}{ll} B_{макс} = 3250 & \text{при } \lambda = 3 \text{ см}, \\ B_{макс} = 32{,}5 & \text{(a) при } \lambda = 30 \text{ см}, \text{ (b)} \\ B_{макс} = 8{,}1 & \text{при } \lambda = 60 \text{ см}. \end{array}$$

Key: (a) with. (b) cm.

Thus, on decimeter waves the resonance rectifiers can be realized only on ferrites with a narrow absorption curve. Besides the weakening of independent phenomena on decimeter waves, additional difficulties appear due to the growth of magnetic losses in ferrites. This is connected with the fact that the resonance field on decimeter waves is small and therefore the ferrite can turn out to be in conditions when it is not magnetized before saturation (Fig. 6).

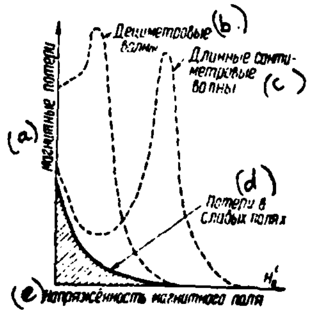

Fig. 6.

Key: (a) Magnetic losses. (b) Decimeter waves. (c) Long centimeter waves. (d) Losses in weak fields. (e) Magnetic field intensity.

In this case additional magnetic losses occur in ferrites, connected with the movement of domain boundaries and natural ferromagnetic resonance, which leads to increase of forward losses and to decrease of rectifier ratio. So that this would be more understandable, let us examine the dependence of magnetic permeability χ=M/H of unmagnetized ferrite on the frequency (Fig. 7). As we will see, two resonances are clearly noticed on curve χ.

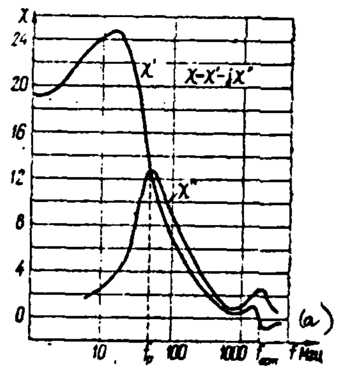

Fig. 7.

Key: (a) MHz.

The first of them (f_p) is obtained blurred, and the curve of virtual component of susceptibility (χ"), characterizing the losses, has large width. This is connected with the fact that resonance

frequencies of different boundary layers of domains differ from each other. The second flash-up χ'' received the name natural ferromagnetic resonance. It is caused primarily by the presence of internal energy of anisotropy in ferrite. If the magnetic moments of separate domains form some angles with the axis of slight magnetization, then they are affected by force, trying to put them along the indicated axis. The action of this force can be replaced by equivalent magnetic field of certain intensity H_a, directed along the axis of slight magnetization.

This field acts on the magnetic moments the same as the external stationary field.

Furthermore, due to heterogeneities in the distribution of magnetization in the ferrite sample, internal demagnetizing fields will appear.

Thus, even with the absence of external magnetic field the phenomenon of ferromagnetic resonance will occur, which is called "natural" resonance.

If the demagnetizing fields are not considered, then the resonance frequency because of the fields of anisotropy will be equal to

$$f_{e.m} = 2{,}8\, H_a\, |\text{Мгц}|,(a) \qquad (5)$$

Key: (a) MHz.

where H_a - intensity of permanent magnetic field in oersteds.

It is clear that for advance of resonance rectifiers in the region of long decimeter waves, materials are needed not only with narrow resonance line, but also with low frequency of natural ferromagnetic resonance. This can be achieved by decrease of constant anisotropy of ferrites and lowering of their magnetization.

The most appropriate ferrites for these purposes are yttrium polycrystals, whose natural ferromagnetic resonance is observed at frequencies 250-300 MHz and the width of the curve is determined by values on the order of 30-50 Oe ($4\pi M_s$=1700 G).

Ferrites of aluminate and chromite (KhM-3, KhMM-1), possessing low saturation magnetization ($4\pi M_s$=500-1000 G), can be used also. Their frequency of natural ferromagnetic resonance lies in the frequency region 700-1000 MHz with width of resonance line 150-250 Oe. The region of overlap of resonance losses and losses in weak fields, as seen from Fig. 6, is increased with growth of wave length. In order to reduce this region, it is necessary to use such a shape

of ferrite, at which the difference between the resonance field and the field, required for magnetic saturation of the sample, is obtained maximum. It is easy to see that in this sense the most advantageous shape is a thin plate, located in plane H. For such a plate [1]

$$H^i_{рез} - H^i_{нас} = H_{\parallel} - H^i_{нас},$$

where $H^i_{нас}$ - internal field, necessary for saturation of ferrite.

For another limiting case of infinitely thin plate, located in plane E, this difference is less, since

$$H^i_{рез} - H^i_{нас} = H\perp - H^i_{нас} < H_{\parallel} - H^i_{нас}.$$

Thus, on decimeter waves it is most advantageous to use ferrites in the form of thin plates, located in plane H.

Characteristics of resonance rectifiers

Depending on the region of application, various requirements are imposed on resonance rectifiers. In connection with this, let us examine several typical versions of the indicated devices.

Rectifiers with low KSV. In a number of cases (for example, in radiorelay communication lines, in measurement technology), when a high degree of matching of separate elements of the waveguide channel

is required, reflections from the ends of the resonance rectifier should be very small (KSV ⩽ 1.03). This is achieved by selection of the shape and dimensions of the ferrite-dielectric plate. Experiments show that the best results can be obtained with the use of plates, located in plane E and not touching the wide walls of the waveguide. Fig. 8 shows the characteristics of a rectifier of such type, developed for the eight-centimeter range of waves.

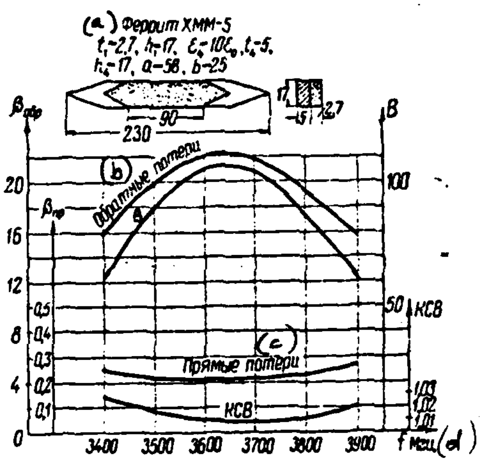

Fig. 8.

Key: (a) Ferrite KhMM-5. (b) Back losses. (c) Forward losses. (d) MHz.

As we see, in the frequency band 14 o/o the KSV of the rectifier does not exceed 1.03, which is achieved mainly by the correct selection of slopes of the dielectric plate, dimensions * of which are shown in

the same figure (at the top). On should note that the shape of the ferrite plate affects the KSV considerably less, since the dielectric permeability and the thickness of ferrite is small.

FOOTNOTE * All dimensions are expressed in millimeters. This note pertains also to subsequent figures. ENDFOOTNOTE

The attachment of the two-layer plate in the waveguide is accomplished with the aid of dielectric bushings, passing through small openings in the narrow wall of the rectangular waveguide.

The rectifier ratio of the examined device is very high. At the central frequency it is equal to approximately 100, which is close to maximum theoretical value $B_{макс}$. computed taking into account dielectric losses. This is achieved by the appropriate selection of parameters of the dielectric plate, and also by decrease of the height of the two-layer plate to a value, comprising approximately 0.6-0.65 of the height of the waveguide. It was already noted [1] that with such height the rectifier ratio reaches maximum value.

Broadband rectifiers. During the creation of resonance rectifiers, operating in a wide frequency band, it is necessary to

use the most active dielectrics possible, providing constant configuration of the magnetic field in ferrite for forward wave. In this case the losses of forward wave will remain constant with change of frequency.

In the resonance rectifier, characteristics of which are presented in Fig. 9, there is used a two-layer plate of approximately the same shape as in the rectifier examined above.

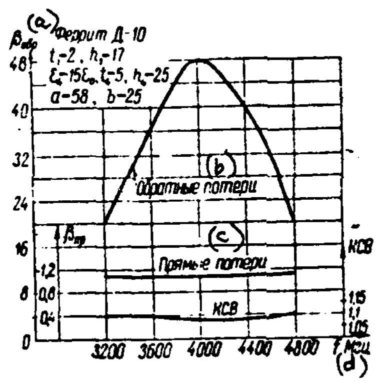

Fig. 9.

Key: (a) Ferrite D-10. (b) Back losses. (c) Forward losses. (d) MHz.

However, the dielectric plate here is more active $(\varepsilon_4 = 15\,\varepsilon_0)$ and has full height. From the presented characteristics we see that forward losses in the 40 o/o frequency band remain approximately constant, and back losses in this same band do not drop below 20 dB. In the three-centimeter wave range dependences of losses on the frequency

are obtained the same, and parameters of the rectifier are determined by the following values: forward losses have the order of 0.8 dB, back losses vary from 25 dB to 33 dB in frequency band 43 o/o (from 8000 MHz to 12400 MHz), and the KSV in the same frequency band varies from 1.1 to 1.2. For the creation of broader band rectifiers it is necessary to take special measures, improving the frequency characteristic of back losses, which, as was already noted, is determined by the shape of the curve of resonance absorption for the back wave.

Rectifiers with large rectifier ratio, as was shown above, can be realized by means of achieving a difference between the resonance fields of forward and back waves. In Fig. 10 are presented the characteristics of such a rectifier, developed for the eight-centimeter wave range.

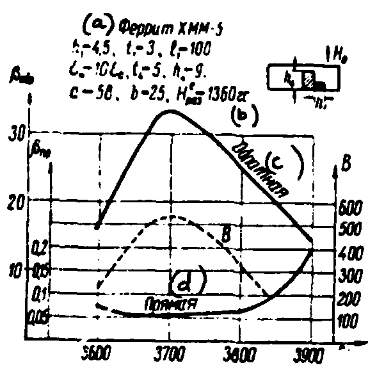

Fig. 10.

Key: (a) Ferrite KhMM-5. (b) G. (c) Back. (d) Forward.

As we see, at the central frequency the rectifier ratio is over 500. This value is several times larger than for the best rectifiers, in which the above-indicated phenomenon is not used. In the examined rectifier both plates are glued to the wide wall of the rectangular waveguide, as is shown in Fig. 10 (at the top), and the ferrite plate is located in plane H. The dimensions of the two-layer plate and the magnetization of ferrite are selected on the basis of experimental results, stated in [2].

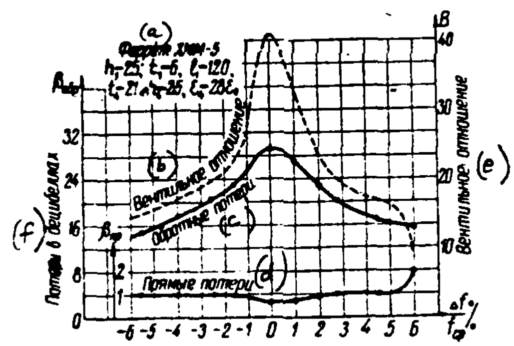

Fig. 11.

Key: (a) Ferrite KhMM-5. (b) Rectifier ratio. (c) Back losses. (d) Forward losses. (e) Rectifier ratio. (f) Losses in decibels.

In Fig. 11 are presented the characteristics of a similar rectifier for decimeter waves *.

FOOTNOTE * This rectifier and the rectifiers of the three-centimeter range presented below are developed by M. M. Koblova. ENDFOOTNOTE

In this rectifier the resonance of forward and back waves also sets in at different fields, which is achieved by means of selection of dimensions and parameters of the two-layer plate. The rectifier ratio at the central frequency is over 40, which is considerably higher than "limiting", which even without taking into account dielectric losses is equal to

$$B_{\text{макс}} = 2\frac{306}{125} = 24.$$

A similar rectifier for the three-centimeter wave range is examined somewhat below.

One should recall that the realization of high rectifier ratios is inevitably connected with deterioration of the range properties of the rectifier, which follows from the results of experimental research of phenomenon of the separation of resonance fields [2].

Rectifiers on raised levels of power. During the creation of rectifiers for operation at raised power levels the ferrite plates

should be arranged in plane H, gluing them to the wide walls of the waveguide. In this case is accomplished good heat removal from the ferrite to the waveguide and warm-up of ferrite due to the power dispersed in it occurs in the allowable limits. Furthermore, one should use temperature stable ferrites, and it is necessary to try to select the shape of their cross section so that the parameters of the rectifier would be little sensitive to change of magnetization, i.e., temperature (Fig. 5). These requirements are fulfilled in the rectifier, the characteristics of which are presented in Fig. 12.

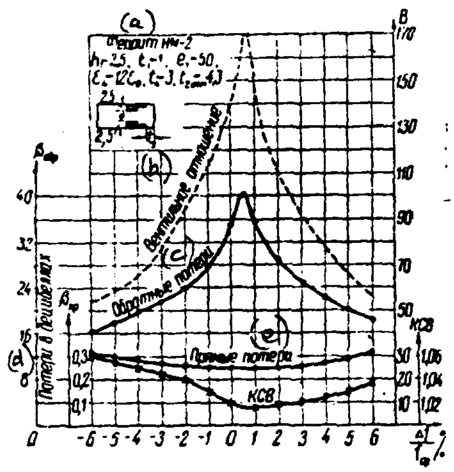

Fig. 12.

Key: (a) Ferrite NM-2. (b) Rectifier ratio. (c) Back losses. (d) Losses in decibels. (e) Forward losses.

It can operate with power of the forward wave in a pulse on the order

of 100 kW (P_{cp} = 100 W) and back wave power around 10 kW (P_{cp} = 10 W). Thus, without overheating the ferrite plates can disperse power on the order of 15-20 W.

In the examined rectifier measures are also taken for the obtaining of good electrical characteristics. The height of the plate and the type of ferrite are selected so that the resonance of forward and back waves would set in at different fields, which made it possible to realize high rectifier ratio (on the order of 170 in the middle of the range). The application of two dielectric (and ferrite) plates provided a high level of back losses with small length of the rectifier, and also approximate constancy of forward losses in a rather wide frequency band.

The rectifiers reach low KSV due to correctly selected slopes of the dielectric plates.

The presented characteristics are kept constant in a wide temperature range, which is provided by the rational selection of average temperature, at which adjustment of the rectifier is performed, shape of plates and by the use of temperature-stable ferrite with high Curie point.

Rectifiers of lightened construction. For reduction of the

weight of resonance rectifier, determined mainly by the weight of the permanent magnet, one should use waveguides of not full height. This leads, first of all, to some elongation of the rectifier, since it is necessary to apply quarter-wave junctions for matching it with the waveguides of normal cross section, and, secondly, to lowering of the electric strength of the rectifier. However, in a number of cases these drawbacks are compensated by the indicated benefit in the weight of the magnet.

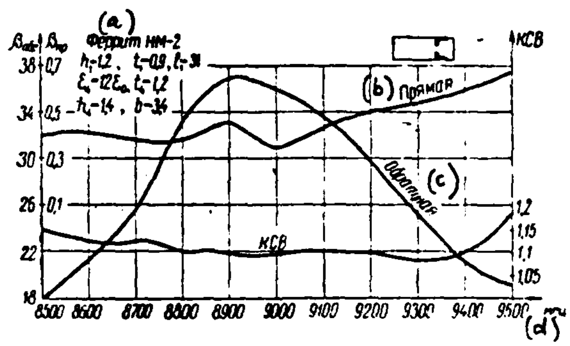

Fig. 13.

Key: (a) Ferrite NM-2. (b) Forward. (c) Back. (d) MHz.

In Fig. 13 are presented the electrical characteristics of one of such rectifiers for the three-centimeter wave range. As we see, the value of KSV here is noticeably higher than with the full height of the waveguide. This is explained, first of all, by the influence of quarter-wave transformers, providing change to waveguide of normal

height, and, secondly, by the incorrect shape of plates, which in view of the small height becomes difficult to manufacture precisely.

Overall view of the examined resonance rectifier is shown in Fig. 14. Its weight is approximately three times less than with full height of the waveguide.

Fig. 14.

In Fig. 15 are presented characteristics of a rectifier of lightened type for the eight-centimeter wave range. They are very close to those, which were presented in Fig. 8 for a similar case of a waveguide with full height. Concerning the value of KSV, in the examined rectifier it also cannot be obtained less than 1.05 for the reasons indicated above.

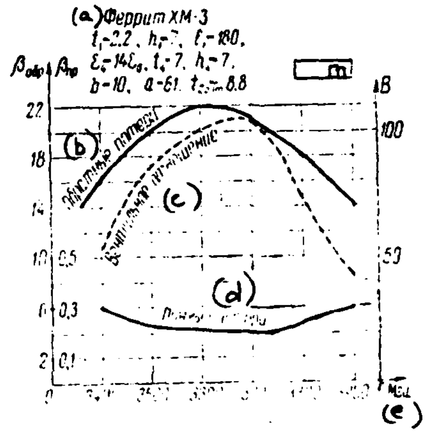

Fig. 15.

Key: (a) Ferrite KhM-3. (b) Back losses. (c) Rectifier ratio. (d) Forward losses. (e) MHz.

In conclusion it is of interest to examine the characteristics of resonance rectifiers, developed by the Raytheon firm. These characteristics are presented in Table 1.

Table 1. Resonance rectifiers of the Raytheon firm.

(a) Полоса частот	(b) Обратные потери		(c) Прямые потери		$B_{макс}$	КСВ	
	(d) мин	(e) макс	(e) макс	(d) мин		(e) макс	(d) мин
350—400	5,7	7,8	0,9	0,8	9,75	1,17	1,12
500—700	7	10	0,9	0,8	14,3	1,25	1,05
1250—1350	13	13	0,45	0,4	32	1,20	1,06
2700—3100	11	13	0,5	0,3	43	1,08	1,05
3400—3600	18,4	26,8	0,8	0,5	54	1,06	1,03
5250—5750	15	23	0,5	0,5	46	1,08	1,05
8500—9600	18	28	0,3	0,25	112	1,1	1,07
8200—12200	19	27	0,8	0,4	67	1,16	1,04

Key: (a) Frequency band. (b) Back losses. (c) Forward losses. (d) min. (e) max.

As we see, the indices of the examined rectifiers, especially on the part of the rectifier ratio, it is impossible to consider high, which, apparently, is connected with the nonoptimum selection of the shape and parameters of ferrite and dielectric plates. The most interesting is the first of the presented rectifiers, intended for operation on waves on the order of 75-85 cm. These for the time being are the longest waves, for which the resonance rectifier is realized.

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